Effect of cold creep on fatigue crack growth behavior for commercial pure titanium

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Abstract

In this paper, the effect of the cold creep on fatigue crack growth rate are investigated by experiment considering wide ranges of load amplitudes and load ratios with or without certain degrees of dwell time. To further illustrate the cold creep influence, a series of finite element results are carried out. Finally fracture morphology analyses are also made to explain related crack growth behavior. Results show that fatigue crack growth rate either increases or decreases with certain degrees of hold load and dwell time imposed, depending on the values of the load amplitude and load ratio. This finding is the same as that in the fatigue life. Discussion shows that the effect of creep on fatigue crack growth can be attributed to the competition of the creep stress relaxation and creep strain. A process of inhibiting and promoting crack growth is performed. The fatigue-creep interaction diagram based on the analyses is depicted, by which the interaction between cold creep and fatigue can be well understood. Finally further studies and discussion are carried out by fracture morphology analyses from the dislocation pile-ups, which is in accordance with the finite element results from local creep behavior. This research will provide support to the clear understanding of the cold creep effects on the fatigue crack growth behavior.

Key words: cold creep; fatigue crack growth; load ratio; load amplitude; dwell time

1. Introduction

Fatigue and fracture due to cyclic loading are the most common failure mode for the engineering structural components. The primary loading parameter affecting the fatigue crack growth is the load ratio, which quantifies the influence of the mean load. It has been known that fatigue crack growth rate either increases or decreases with the value of load ratio increasing [1, 2]. For the constant amplitude loading, some materials display significant load ratio effects that a higher load ratio will result in a faster crack growth rate for the given load amplitude and crack length [3-7]. The fatigue crack growth rate is determined by stresses and deformations at the crack front. Plastic and disruptive processes at the crack tip are responsible for crack propagation. The applicability of the